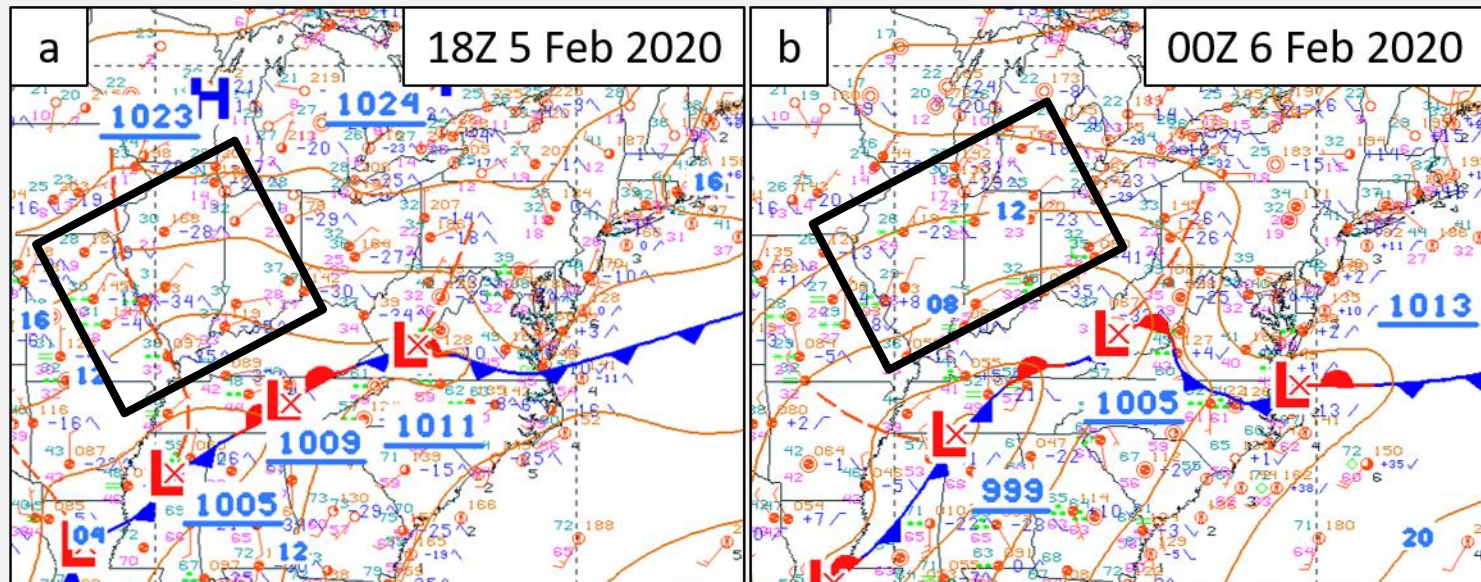# A Study of the Kinematics and Dynamics Associated with Mesoscale Snowbands in a Midwest United States Snowstorm on 5 February 2020

Charles N. Helms, Gerald M. Heymsfield, and Stephen D. Nicholls

NASA Goddard Space Flight Center

14 December 2021

Synoptic Overview

- WPC-analyzed stationary front over SE US

- Large precipitation shield over Midwest US
  - Target for NASA IMPACTS science flight

NASA IMPACTS Field Campaign

See Lynn McMurdie's talk earlier in this session (A23A-02)

- Ongoing field campaign focused on observing snowstorms over the Midwest and Northeast United States

- Platforms:
  - Ground assets (inc. radar, sfc obs, radiosondes)
  - P-3: Midlevel aircraft with in-situ instruments
  - ER-2: High altitude aircraft with remote sensing instruments, including several radars
   - EXRAD (X), HIWRAP (Ku/Ka), CRS (W)

ER-2 Radar Data

- EXRAD
  - ER-2 X-band radar with nadir and conically-scanning beams
    - 3D reflectivity field and horizontal wind retrievals
- VAD wind and deformation retrievals
  - Helms et al. (2020)
  - Combines data from several scans to compute horizontal wind and deformation

Helms, C. N., M. L. W. McLinden, G. M. Heymsfield, and S. R. Guimond, 2020: Reducing errors in velocity-azimuth display (VAD) wind and deformation retrievals from airborne Doppler radars in convective environments. J. Atmos. Ocean Technol., 37, 2251–2266. https://doi.org/10.1175/JTECH-D-20-0034.1

- Specifically, the synthetic multiscan data selection strategy

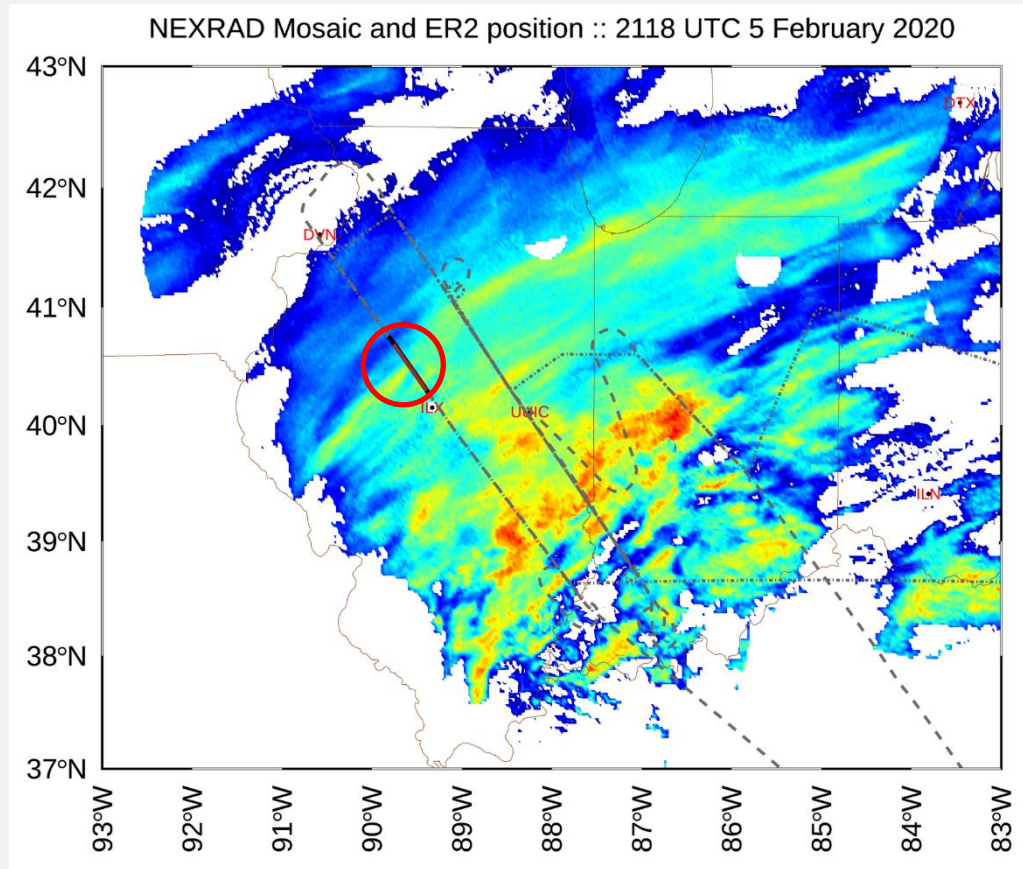# Radar Mosaic – 2028 UTC 5 Feb

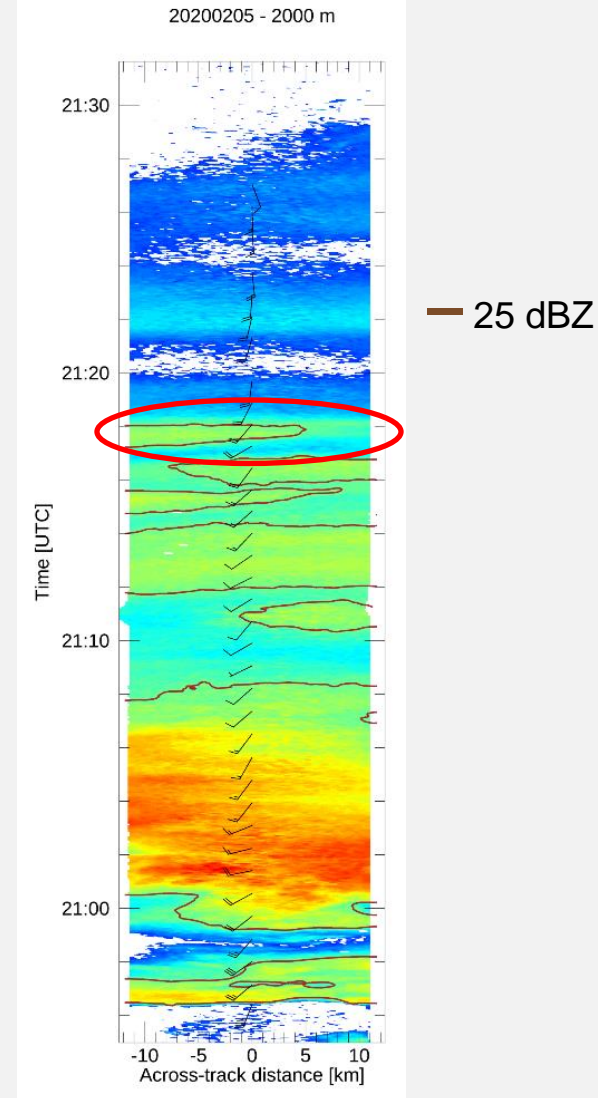NEXRAD Mosaic and ER2 position :: 2028 UTC 5 February 2020
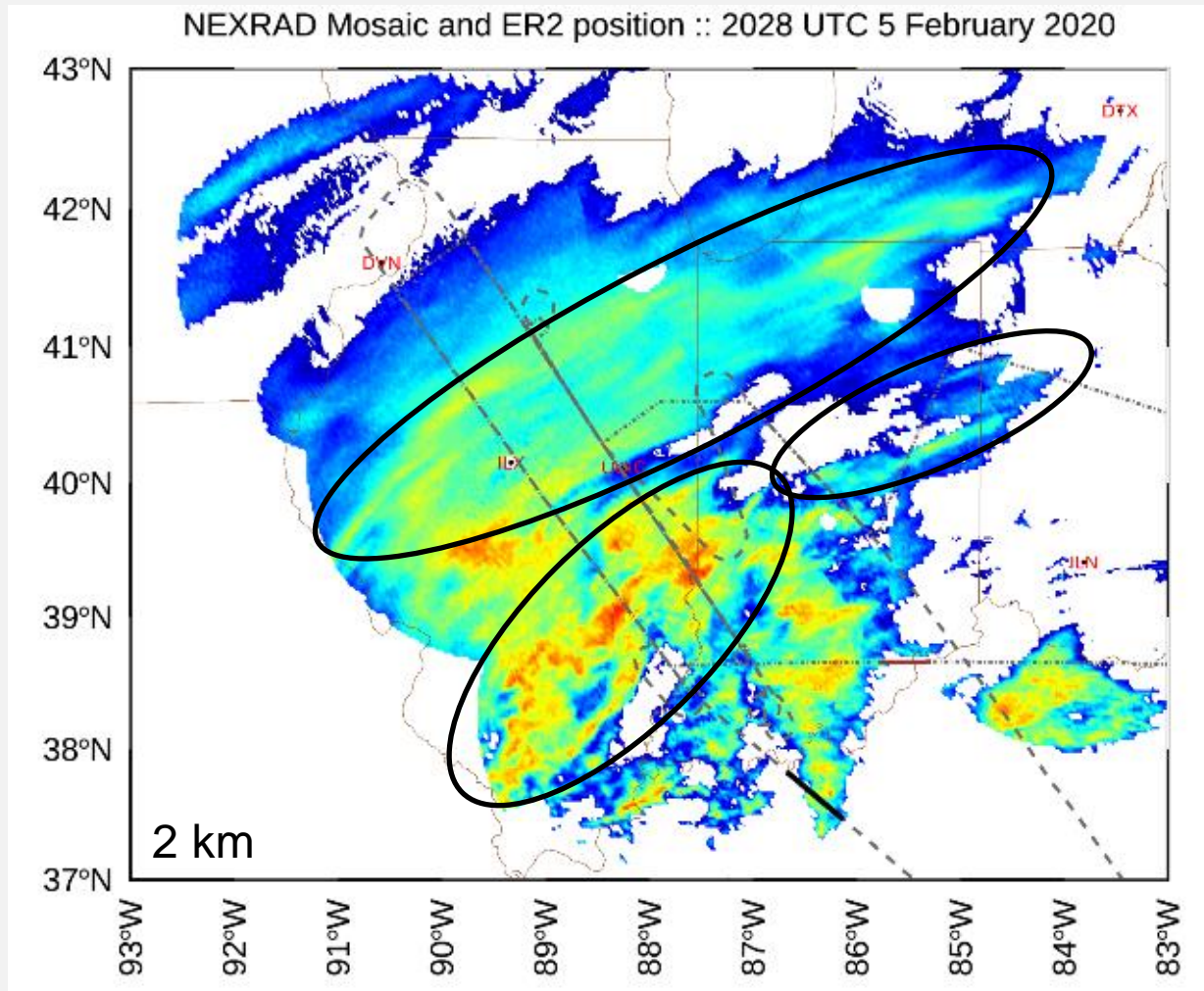
- P3 and ER-2 arrive

- Convective precip. over southern Illinois

- Banding structures over Illinois, Indiana, and Michigan

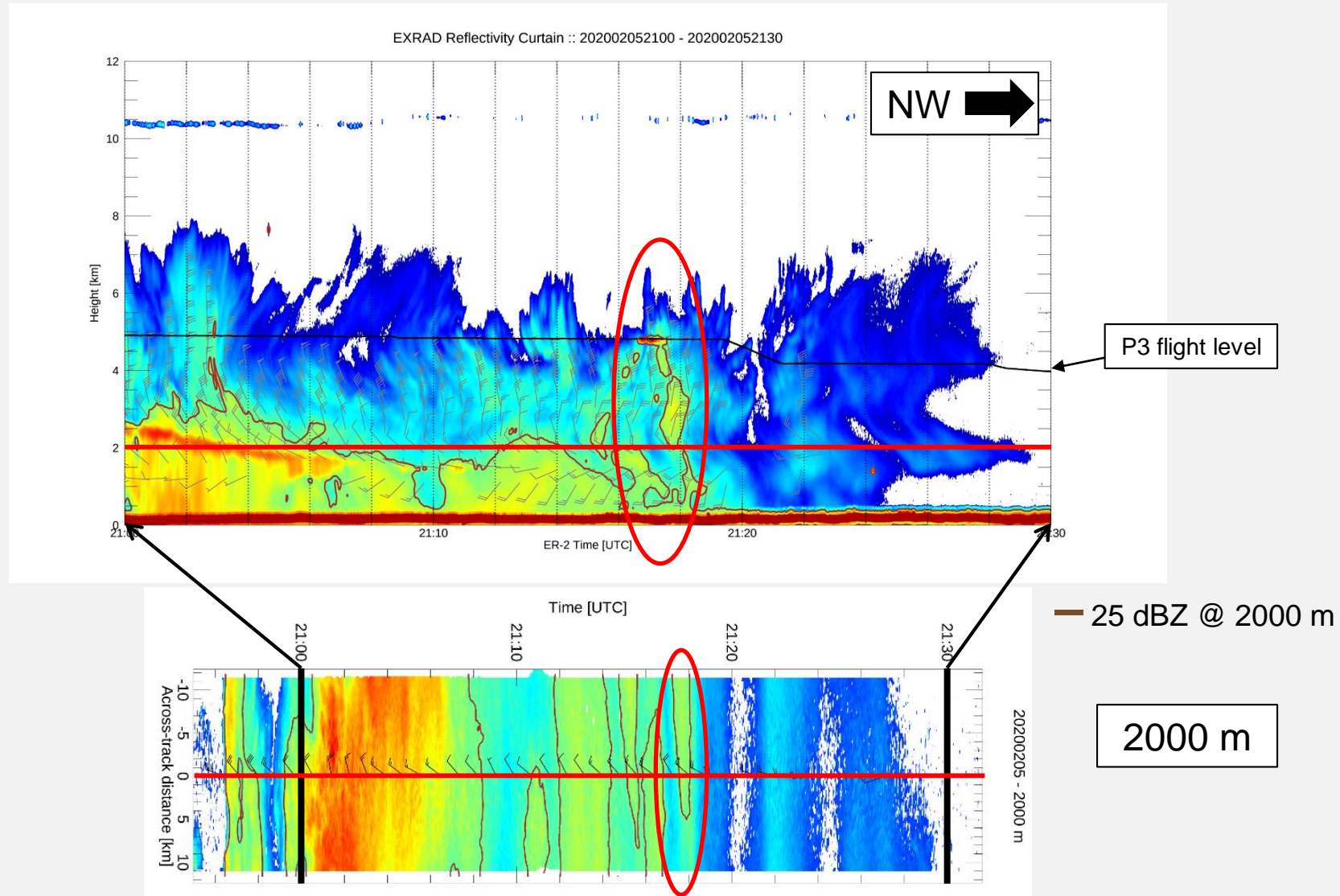Thanks to Stacy Brodzik for providing NWS radar mosaic data
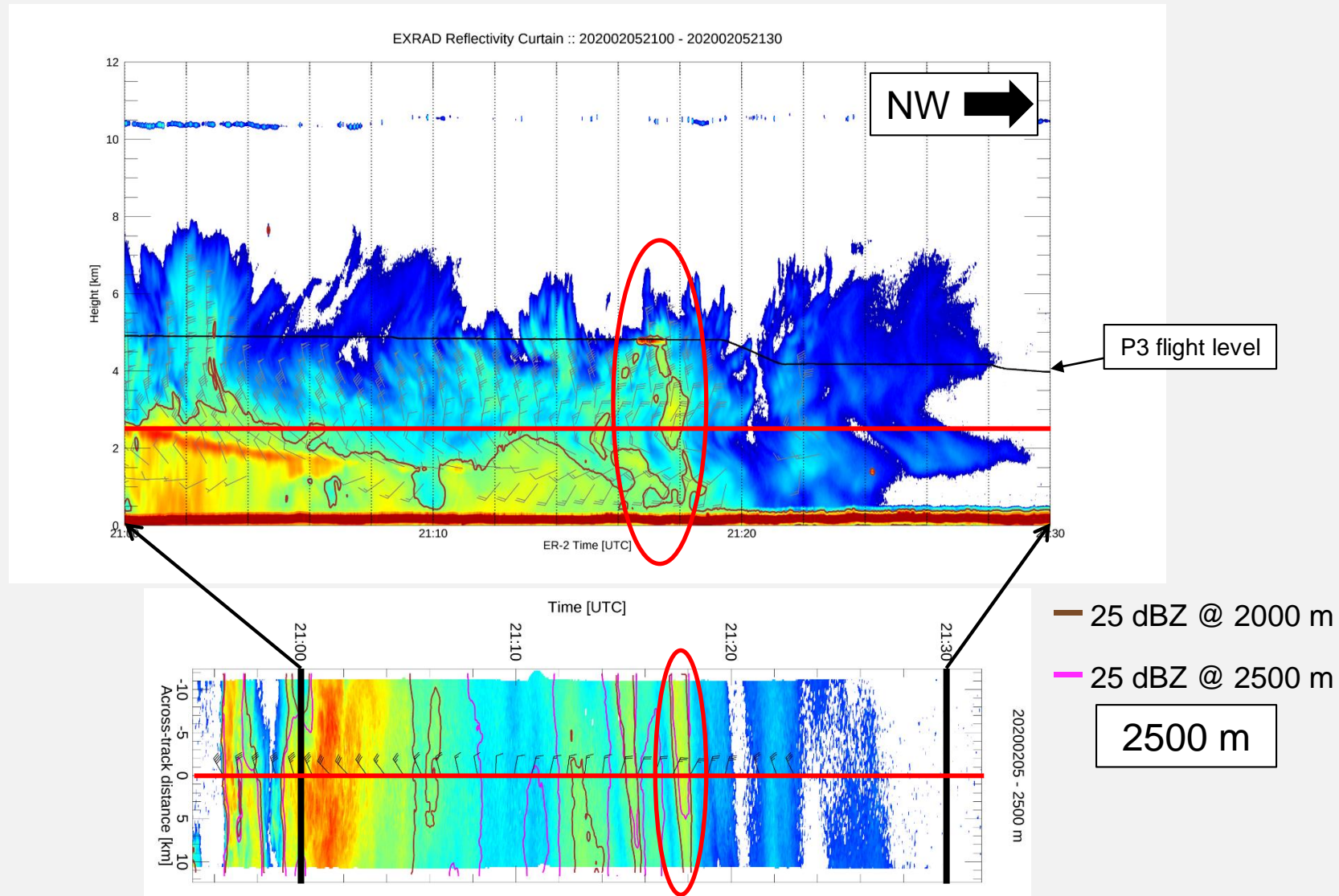
Feature of Interest

NEXRAD Mosaic and ER2 position :: 2118 UTC 5 February 2020

20200205 - 2000 m

— 25 dBZ

- Leading end of a banding feature

What do these features look like?

EXRAD Reflectivity Curtain :: 202002052100 - 202002052130
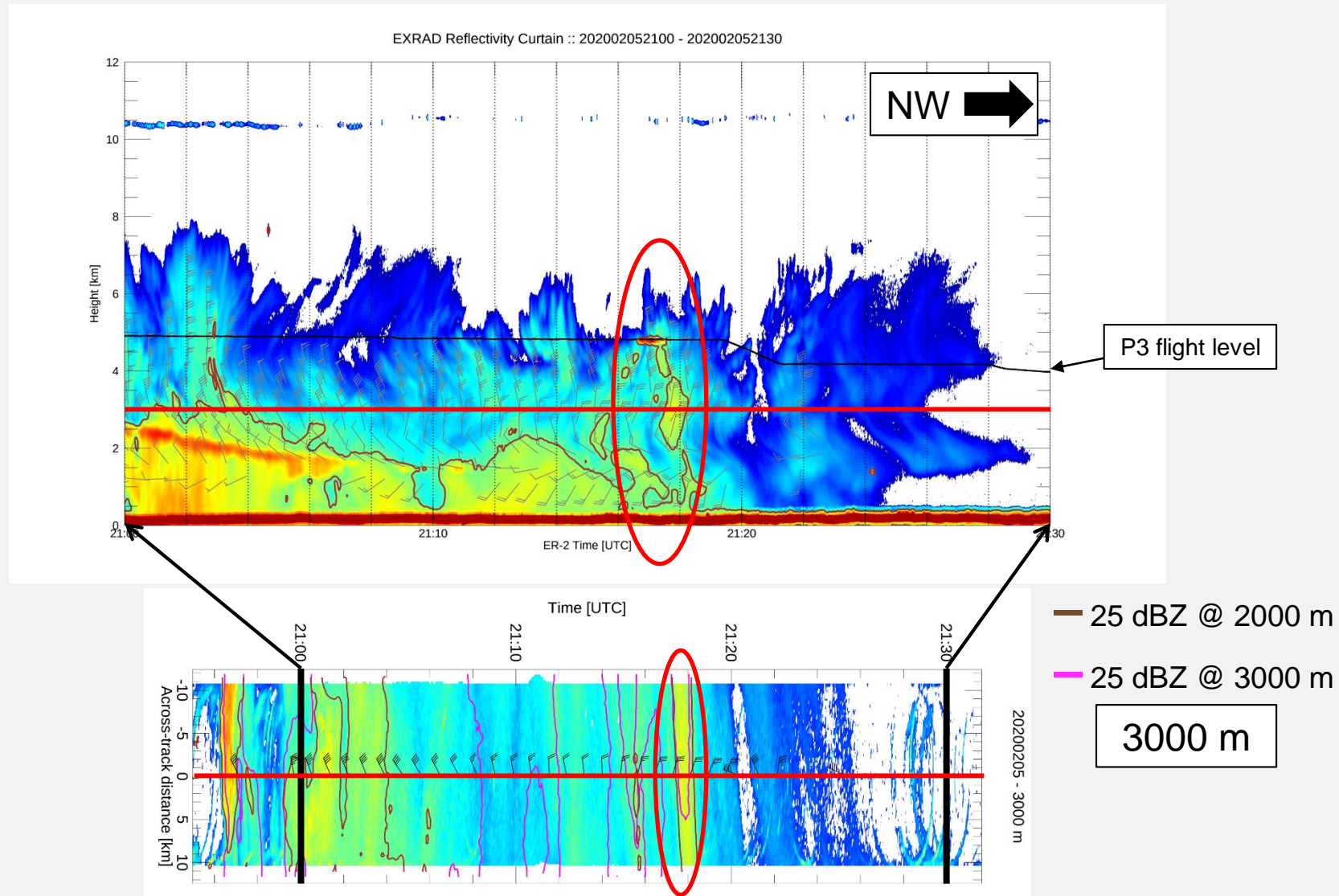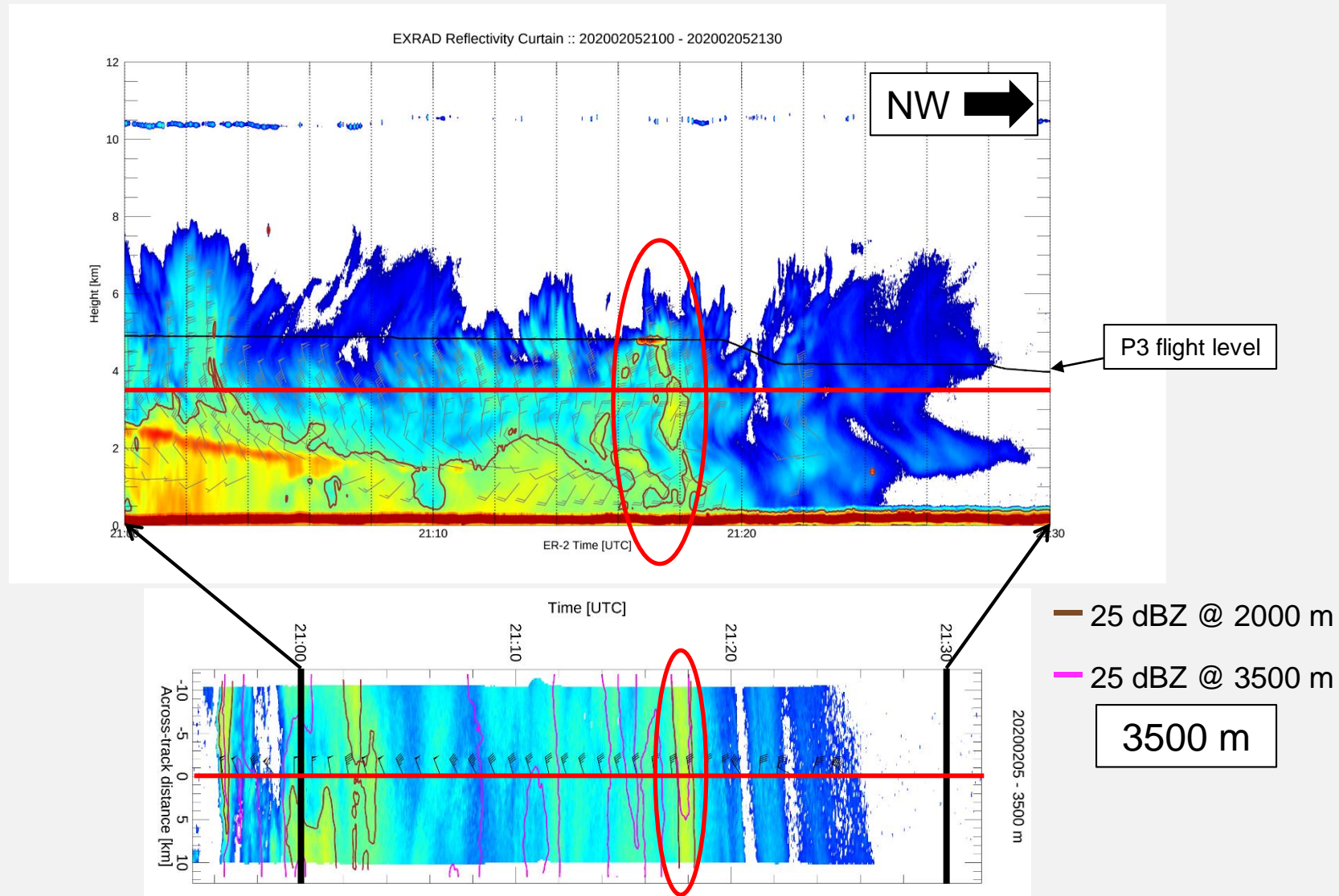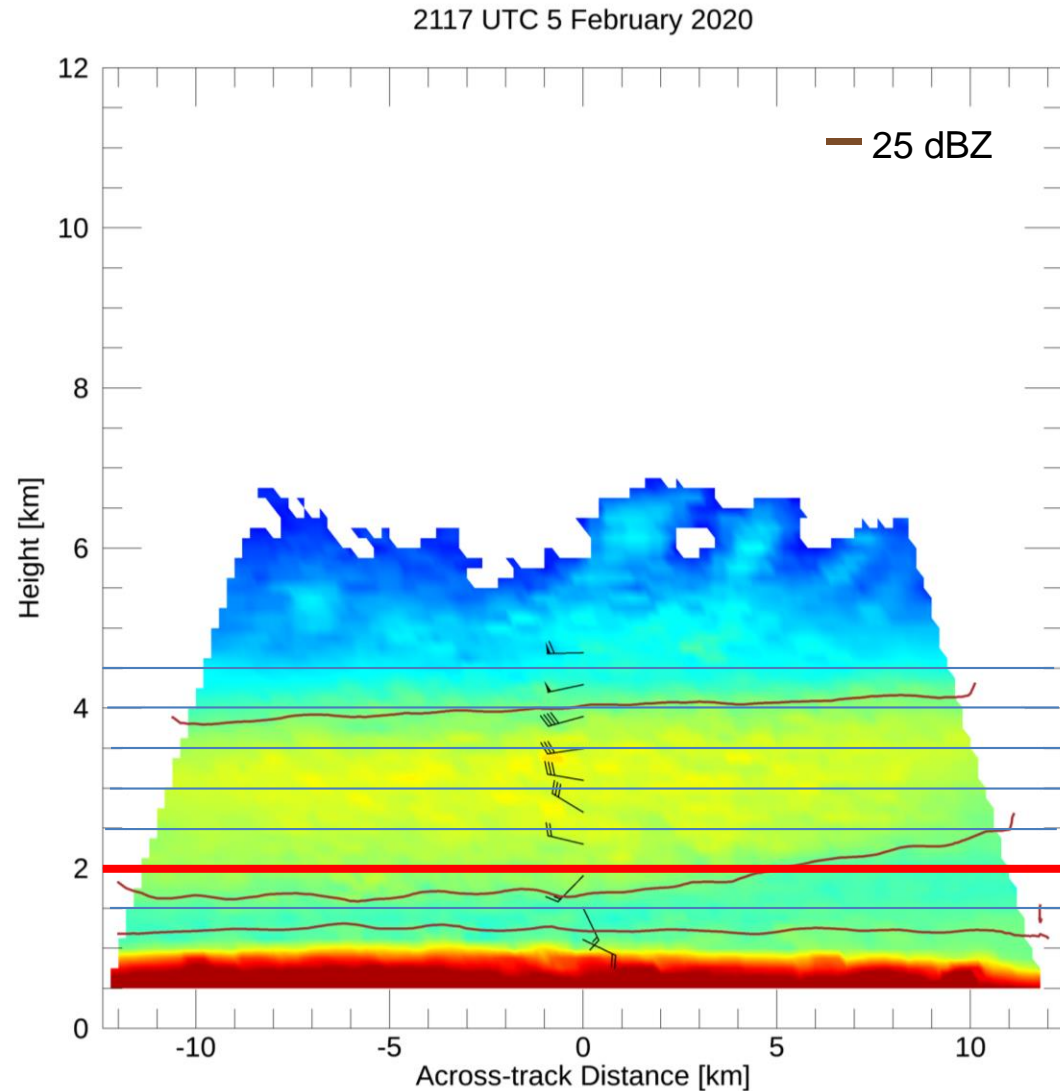
NW ➡

P3 flight level

━ 25 dBZ @ 2000 m

2000 m

What do these features look like?

What do these features look like?

What do these features look like?

EXRAD Reflectivity Curtain :: 202002052100 - 202002052130

NW ➡

P3 flight level

Time [UTC]
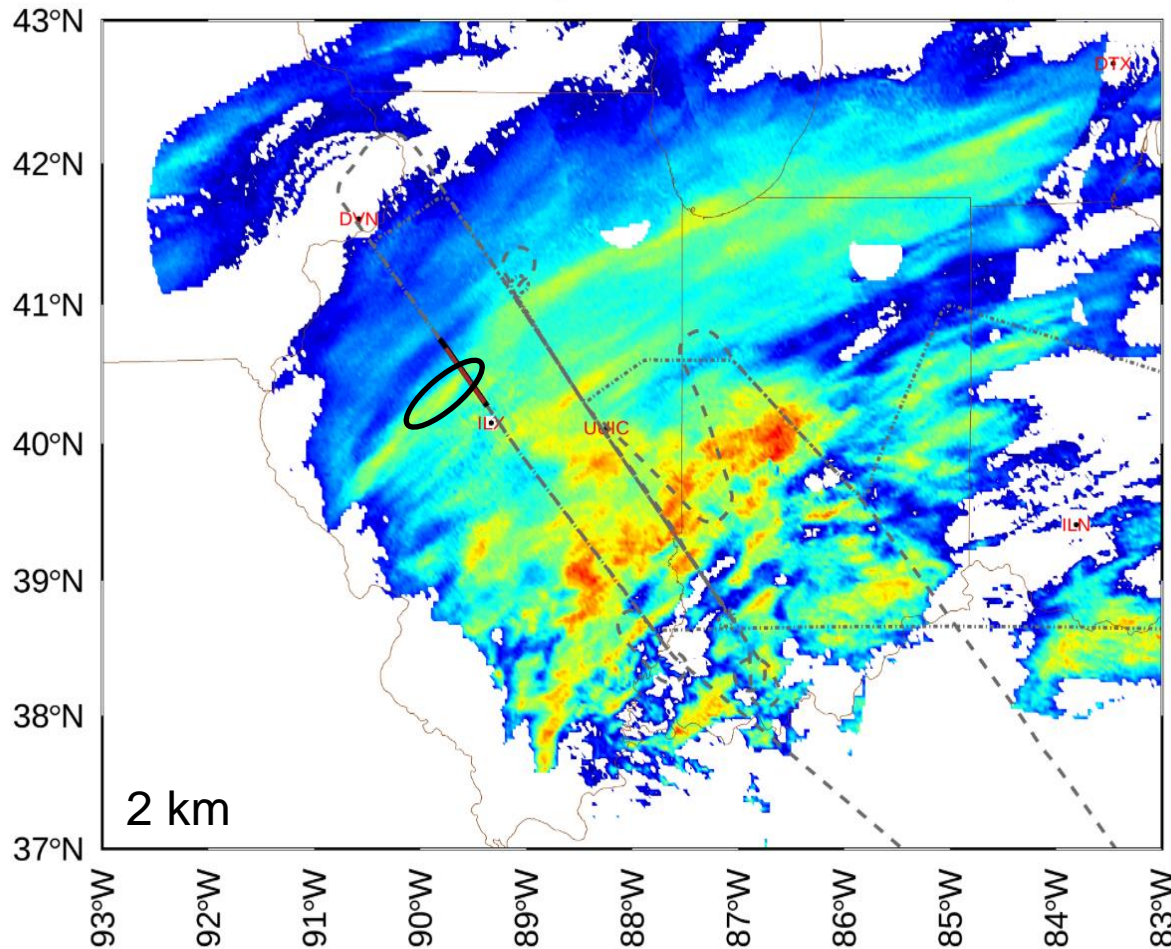
━ 25 dBZ @ 2000 m

━ 25 dBZ @ 3500 m

3500 m

What do these features look like?
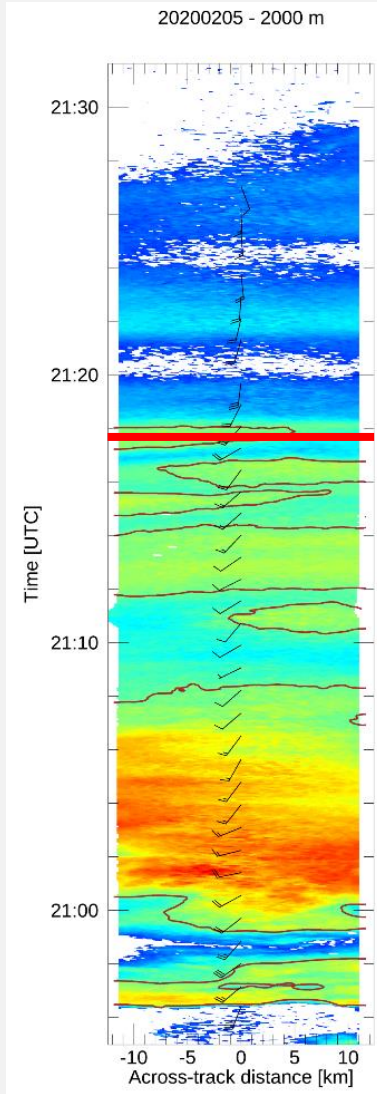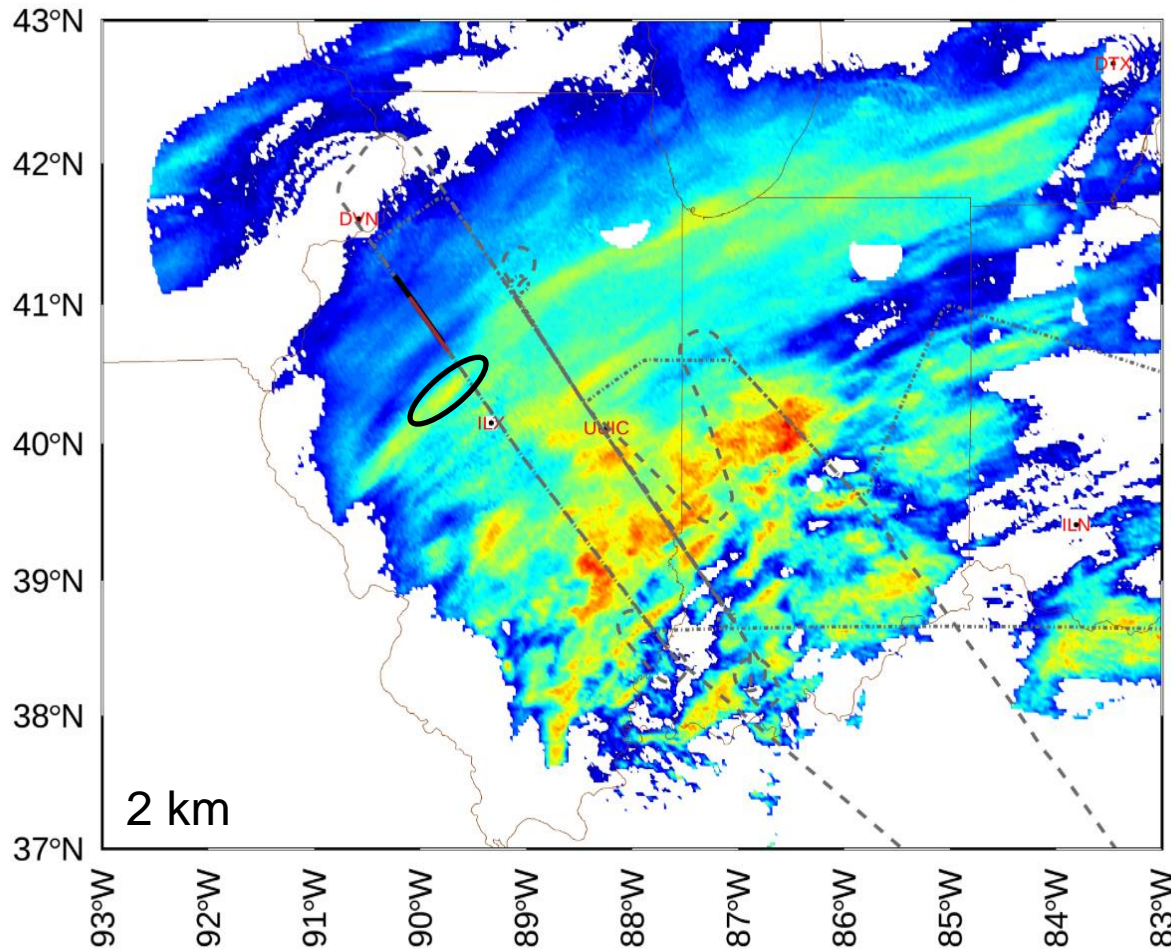
A Second Pass

NEXRAD Mosaic and ER2 position :: 2118 UTC 5 February 2020

- Second leg of flight intersects the same band
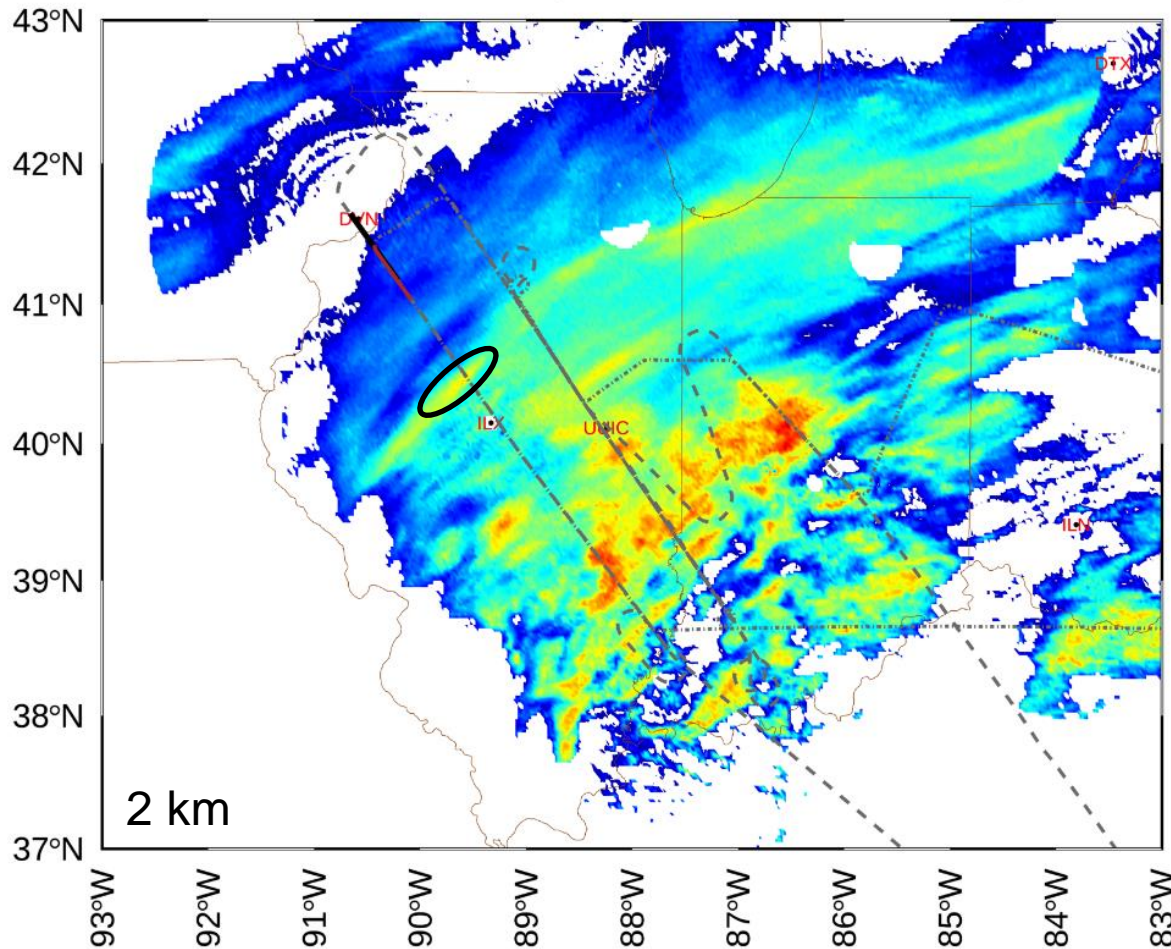
A Second Pass

NEXRAD Mosaic and ER2 position :: 2123 UTC 5 February 2020

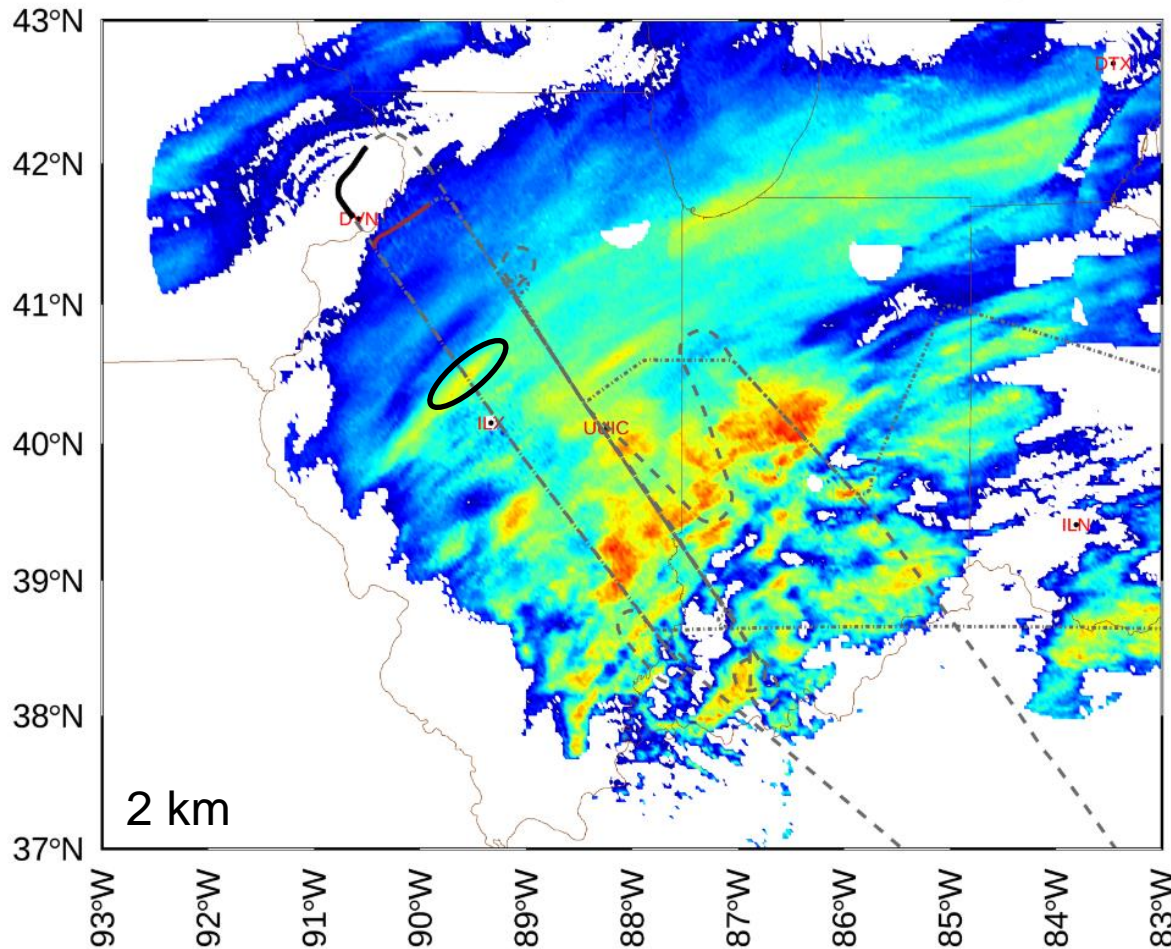- Second leg of flight intersects the same band

A Second Pass

NEXRAD Mosaic and ER2 position :: 2128 UTC 5 February 2020

2 km

- Second leg of flight intersects the same band
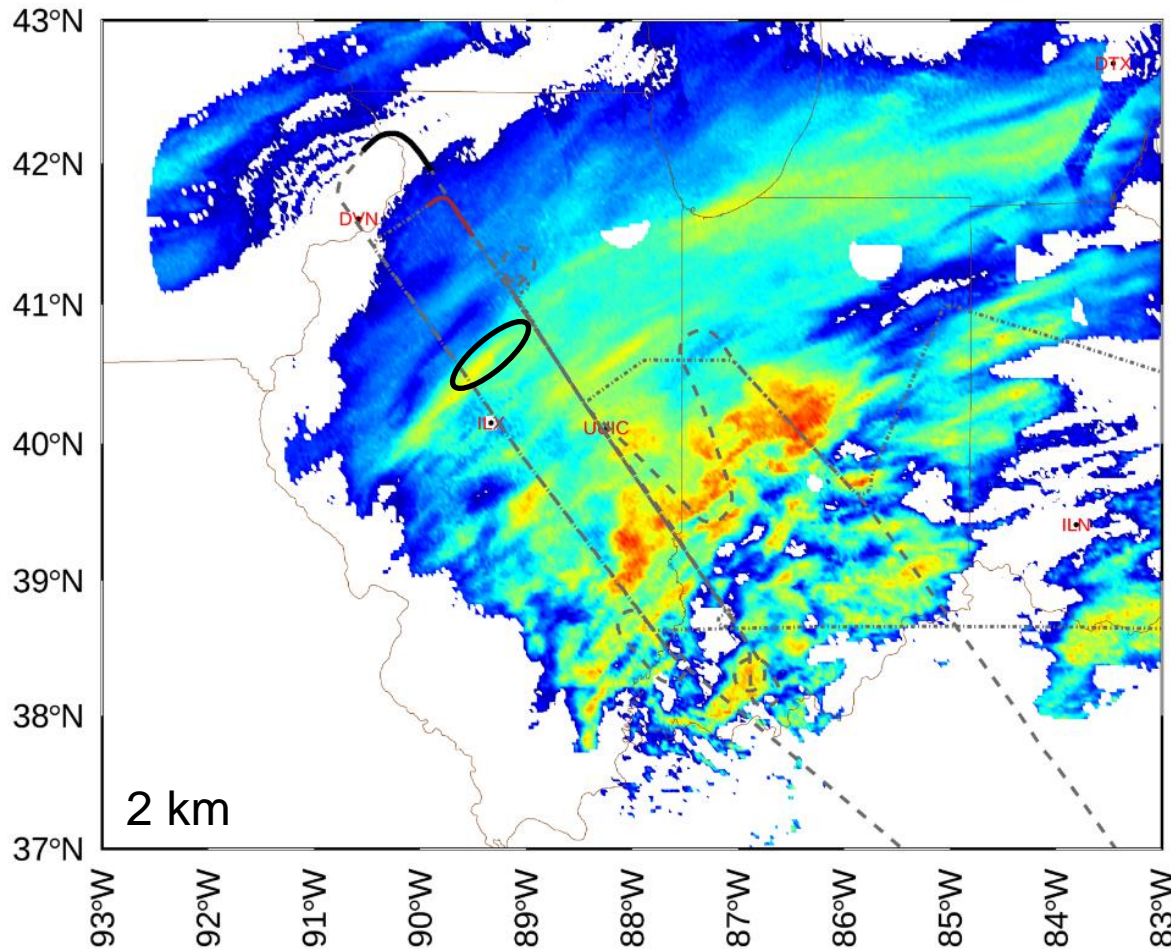
A Second Pass

NEXRAD Mosaic and ER2 position :: 2133 UTC 5 February 2020

2 km

- Second leg of flight intersects the same band
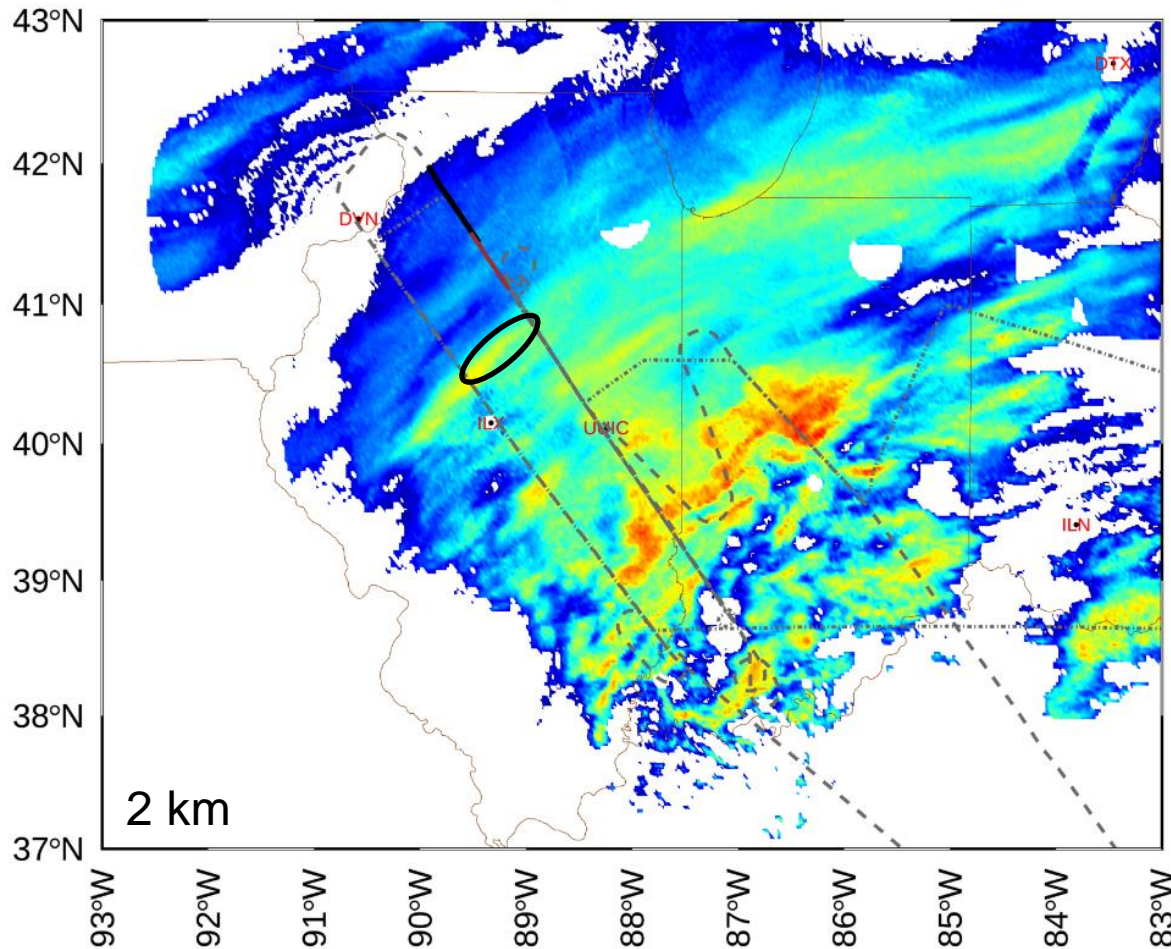
A Second Pass

NEXRAD Mosaic and ER2 position :: 2138 UTC 5 February 2020

2 km

- Second leg of flight intersects the same band

A Second Pass

NEXRAD Mosaic and ER2 position :: 2143 UTC 5 February 2020

2 km

- Second leg of flight intersects the same band
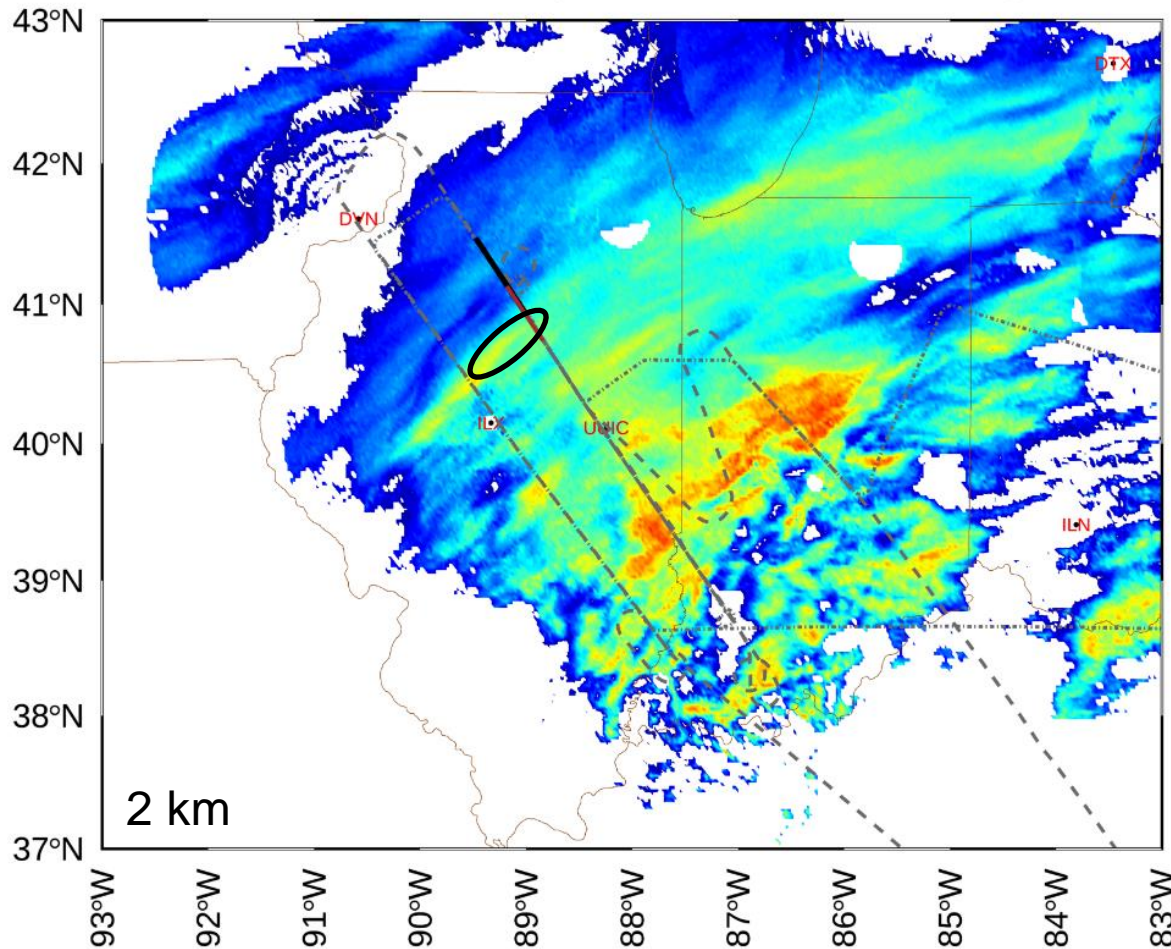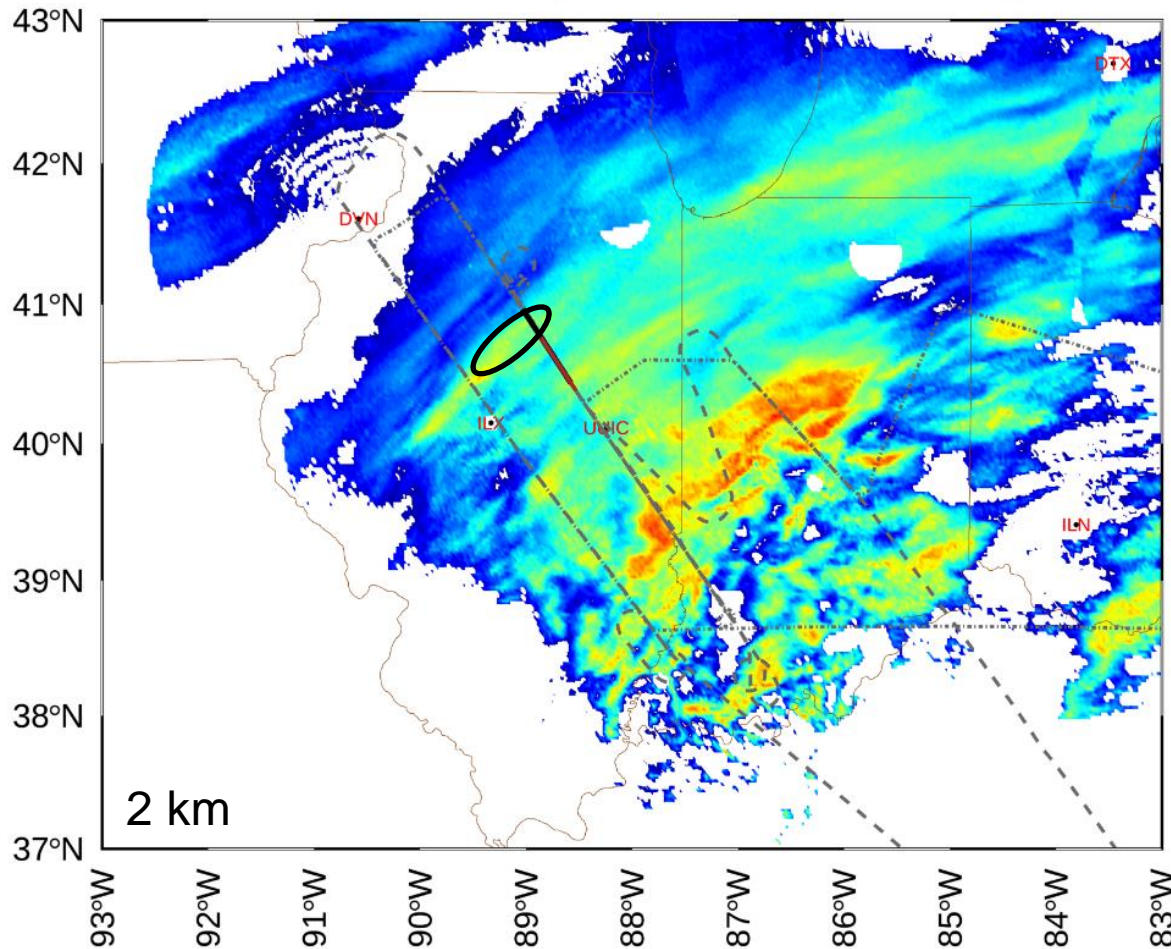
A Second Pass

NEXRAD Mosaic and ER2 position :: 2148 UTC 5 February 2020

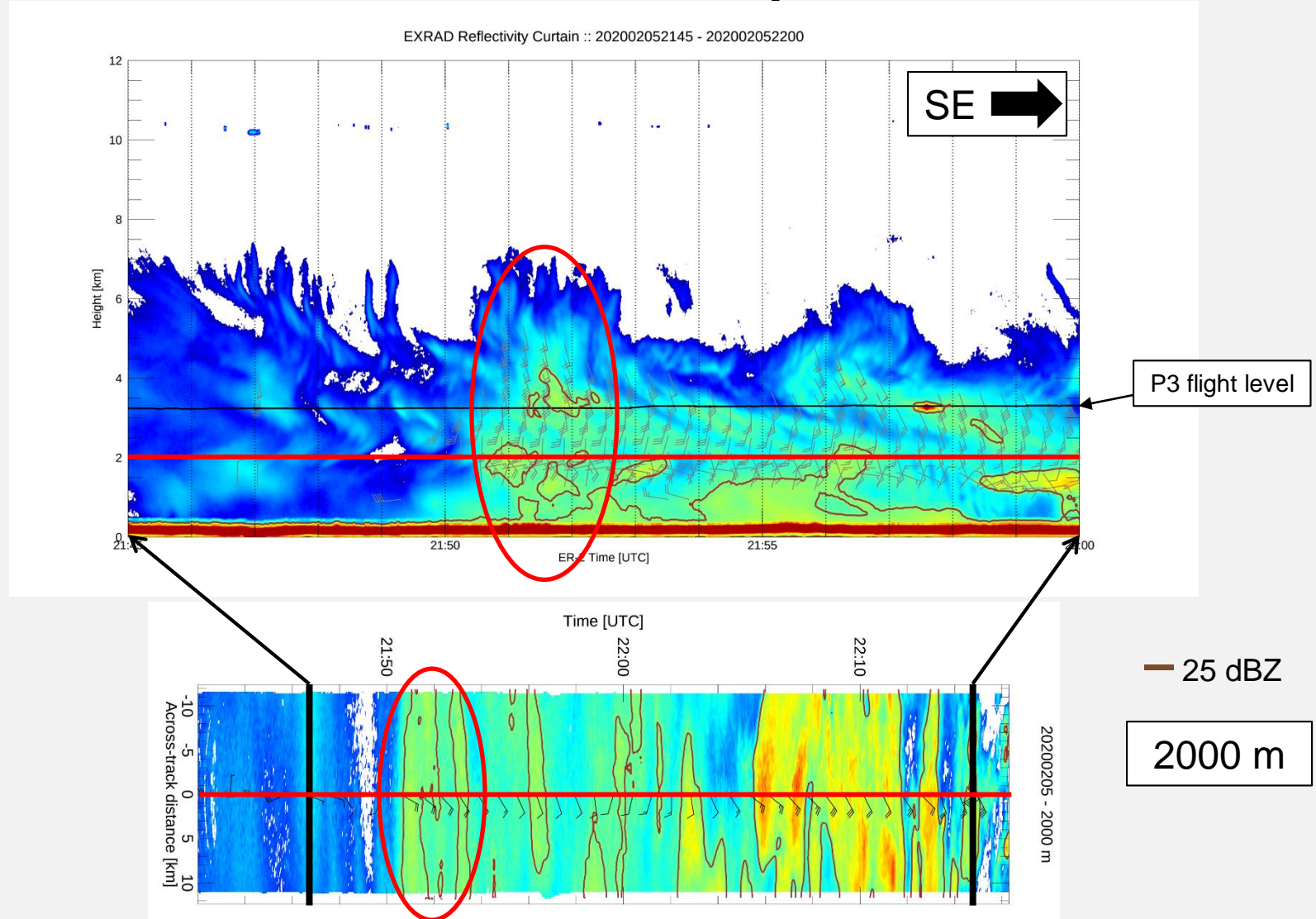- Second leg of flight intersects the same band

A Second Pass
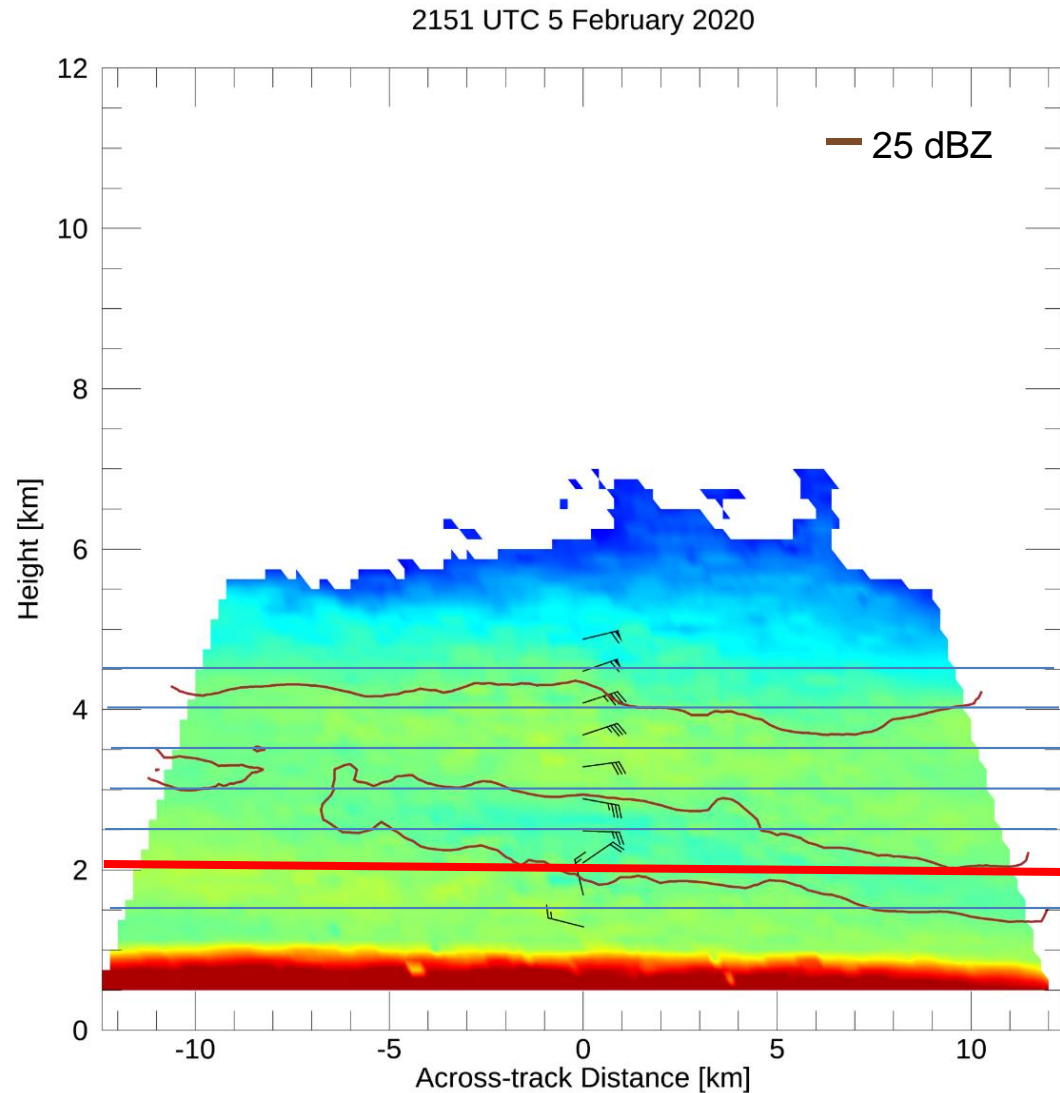

NEXRAD Mosaic and ER2 position :: 2153 UTC 5 February 2020
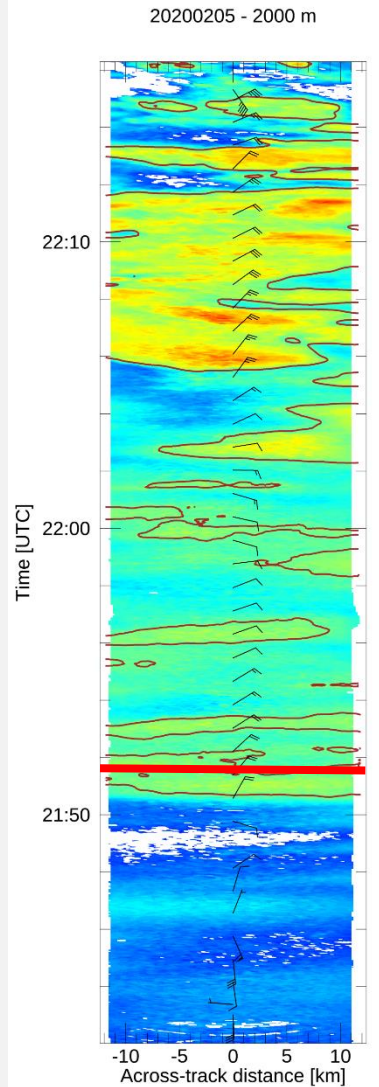
2 km

- Second leg of flight intersects the same band

What does the second pass look like?

EXRAD Reflectivity Curtain :: 202002052145 - 202002052200

What does the second pass look like?

20200205 - 2000 m

2151 UTC 5 February 2020

Why are these bands sloped?

Isentropic lift?

━ 25 dBZ
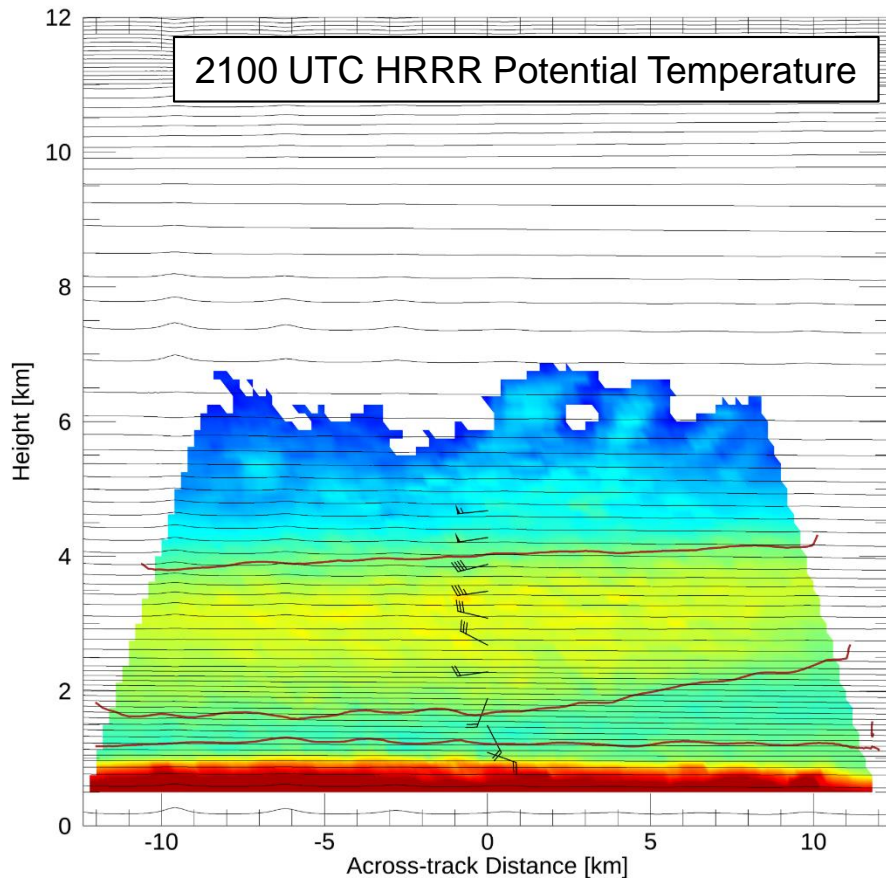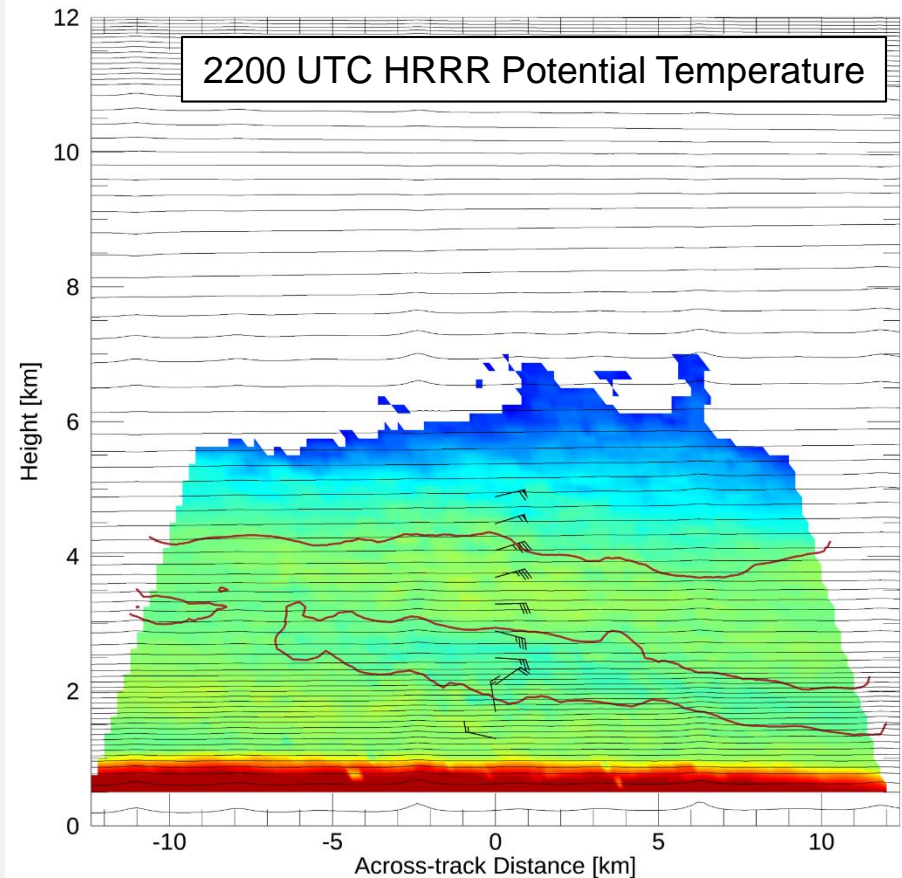
Why are these bands sloped?

Are these gently sloped fall streaks?

2117 UTC 5 February 2020

First Pass — 25 dBZ

Slope: 18 m/km

Slope: 91 m/km
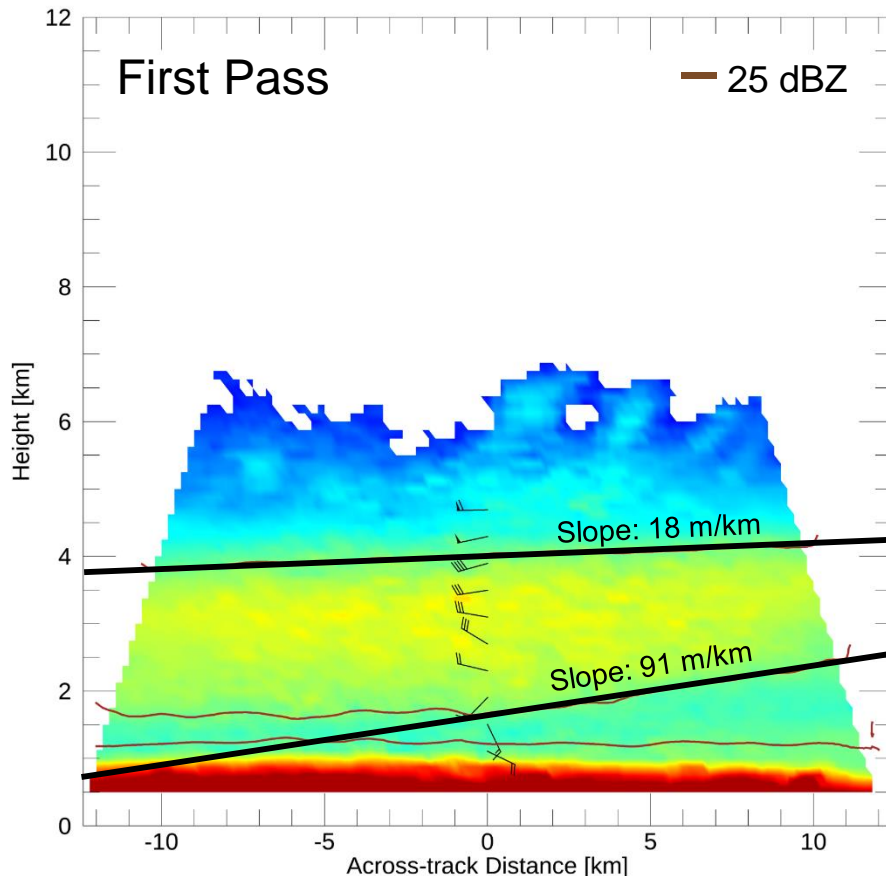
What fall speed (FS) would be needed?

- 2–4-km layer-mean across-track shear: 7.9 m/s/km

- Horizontal displacement rate by shear: ΔD = shear*thickness

- Slope = FS/ΔD or
  FS = slope*ΔD

Fall speed = 0.06 m/s   Very slow
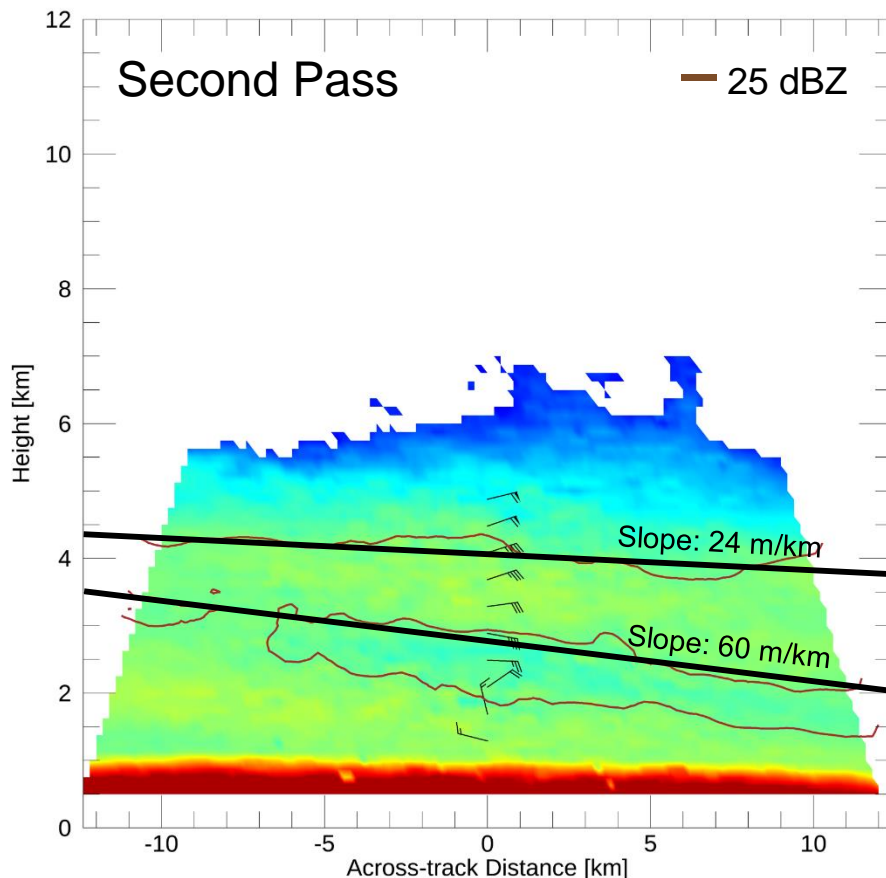
Fall speed = 1.62 m/s   Reasonable

Why are these bands sloped?

Are these gently sloped fall streaks?

2151 UTC 5 February 2020

Second Pass — 25 dBZ

Slope: 24 m/km

Slope: 60 m/km

What fallspeed (FS) would be needed?

- 2–4-km layer-mean across-track shear: 7.8 m/s/km

- Horizontal displacement rate by shear: ΔD = shear*thickness

- Slope = FS/ΔD or
  FS = slope*ΔD

Fallspeed = 0.11 m/s   Slow

Fallspeed = 0.70 m/s   Reasonable

More work needed

Why are these bands where they are?
Deformation features?

First Pass

VAD Total Deformation

EXRAD Reflectivity Curtain :: 202002052100 - 202002052130

NW ➡

— 25 dBZ

Thin magenta contour: 2x10^{-4} s^{-1} Thick magenta contour: 4x10^{-4} s^{-1}
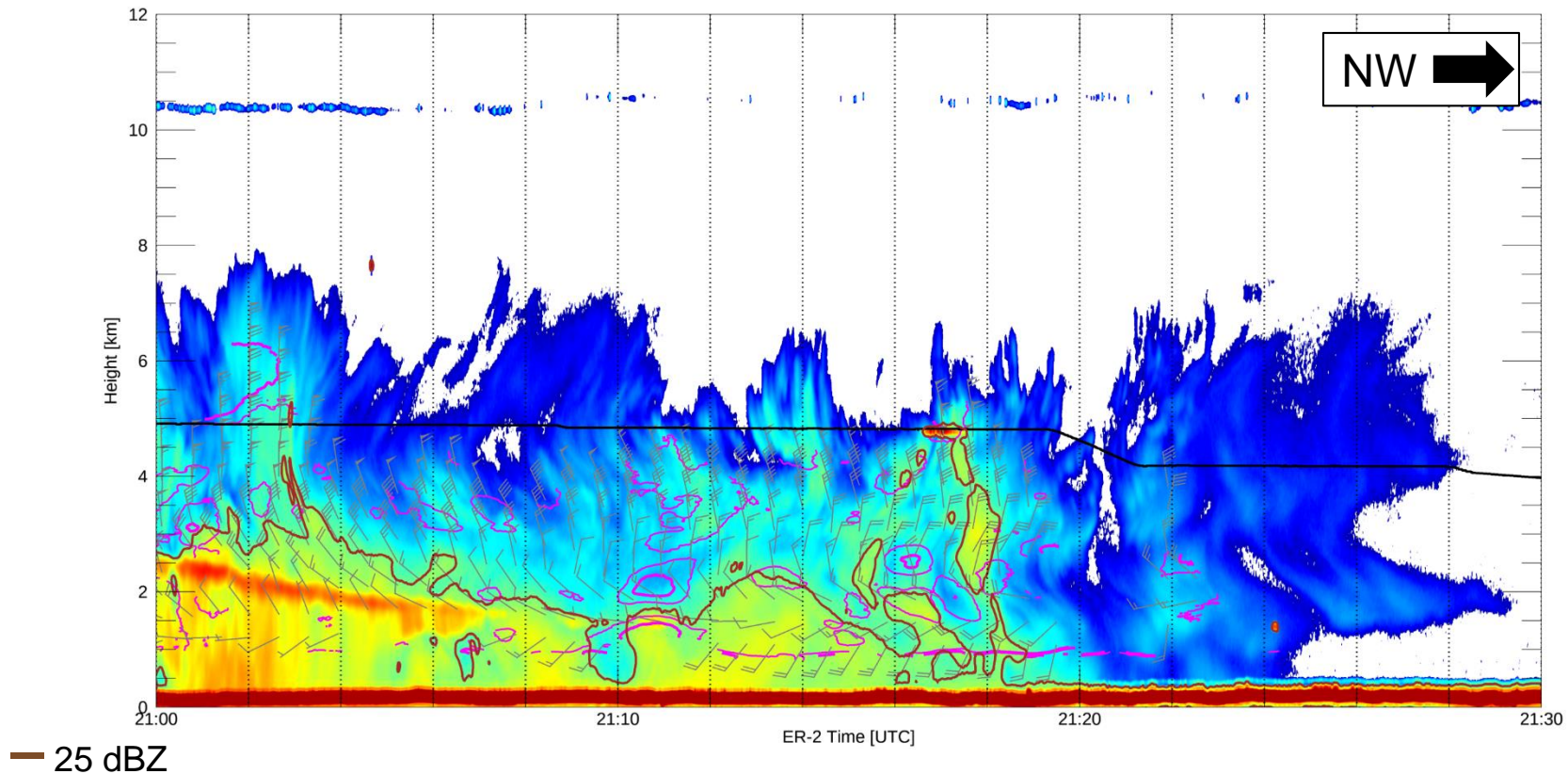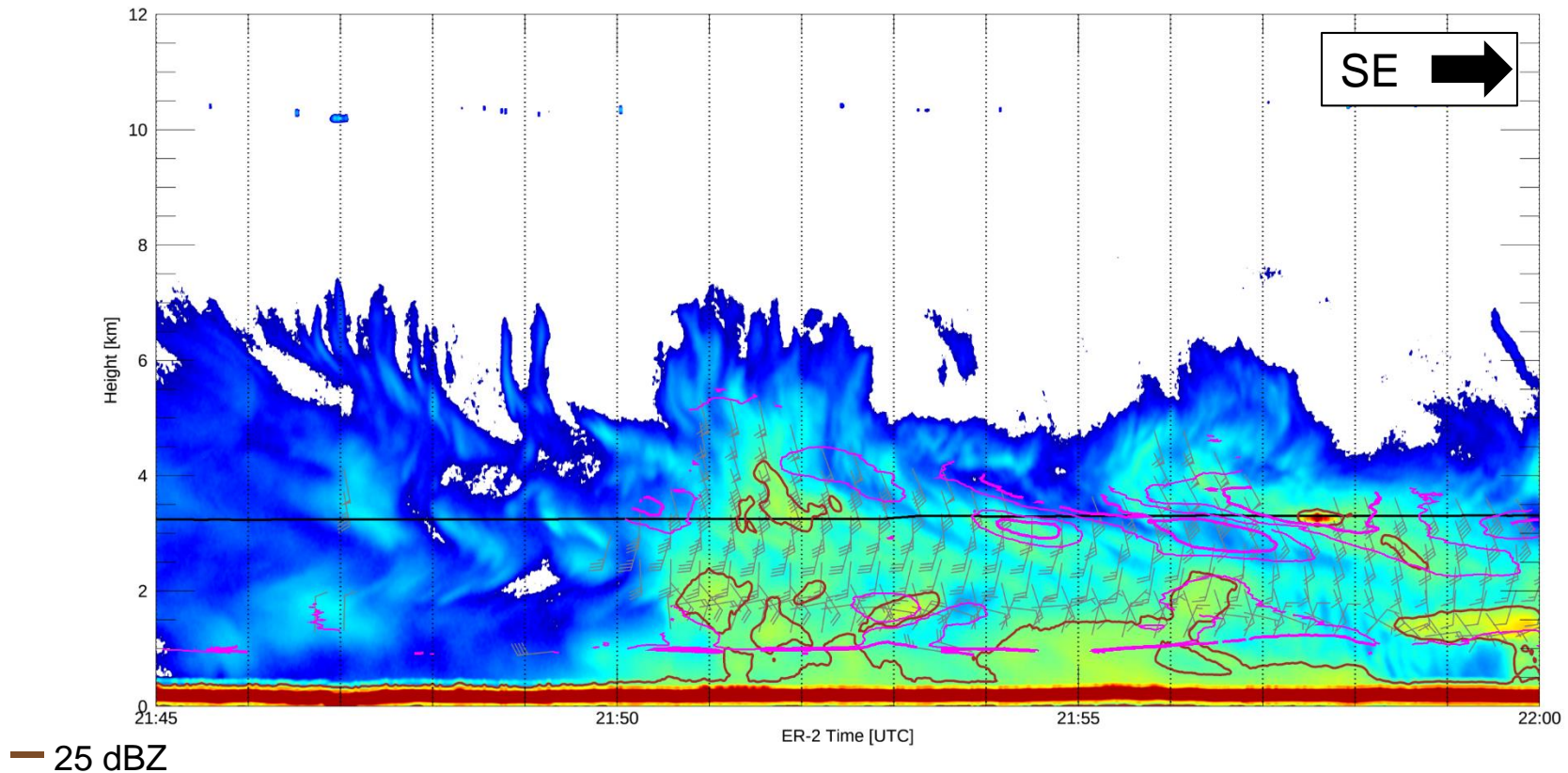
Why are these bands where they are?
Deformation features?

Second Pass — EXRAD Reflectivity Curtain :: 202002052145 - 202002052200 — VAD Total Deformation

SE ➡

━ 25 dBZ

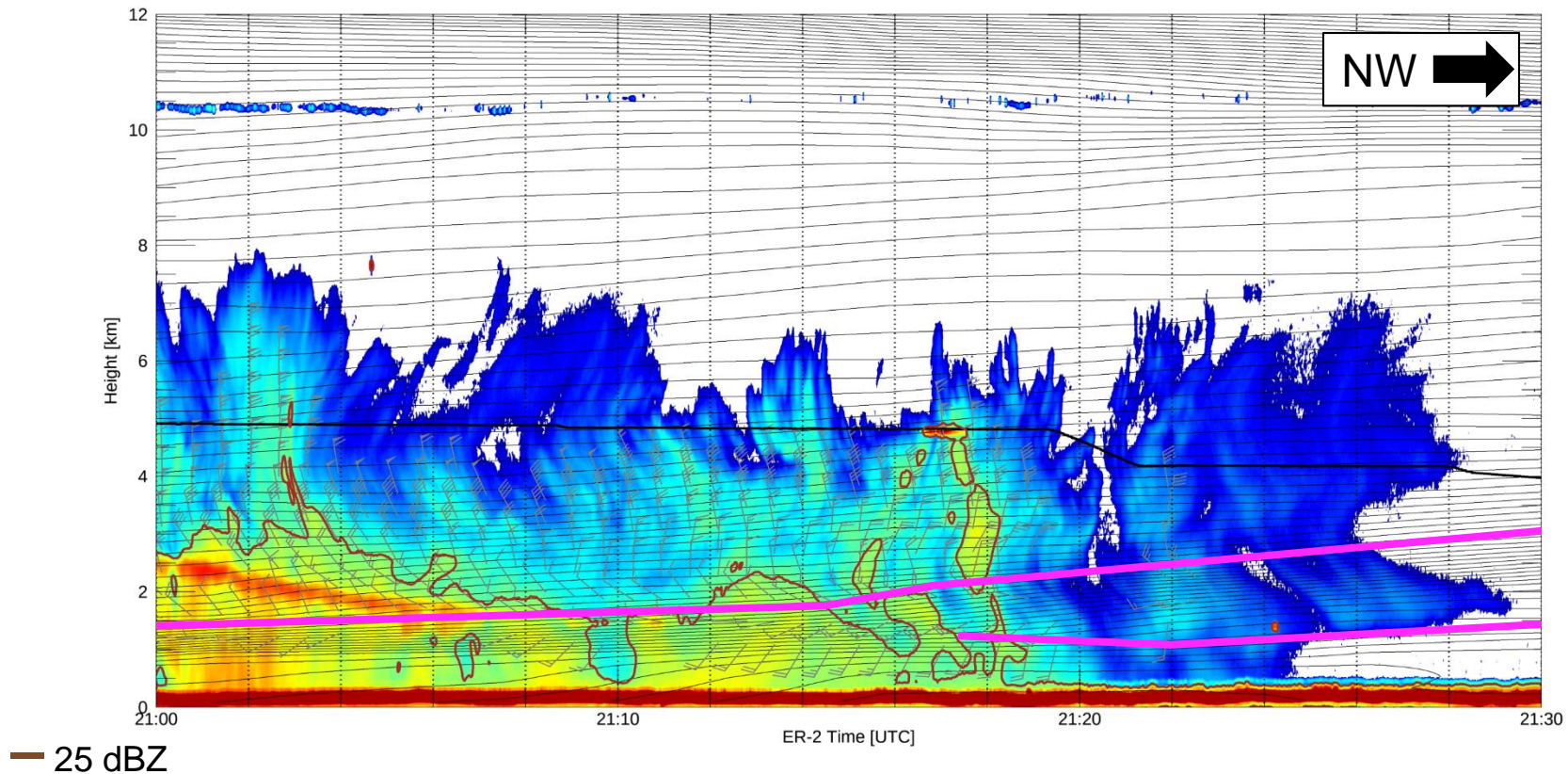Thin magenta contour: 2x10^{-4} s^{-1} Thick magenta contour: 4x10^{-4} s^{-1}

Why are these bands where they are?
Frontal features?

First Pass

EXRAD Reflectivity Curtain :: 202002052100 - 202002052130

21-22 UTC HRRR θ

NW ➡

25 dBZ

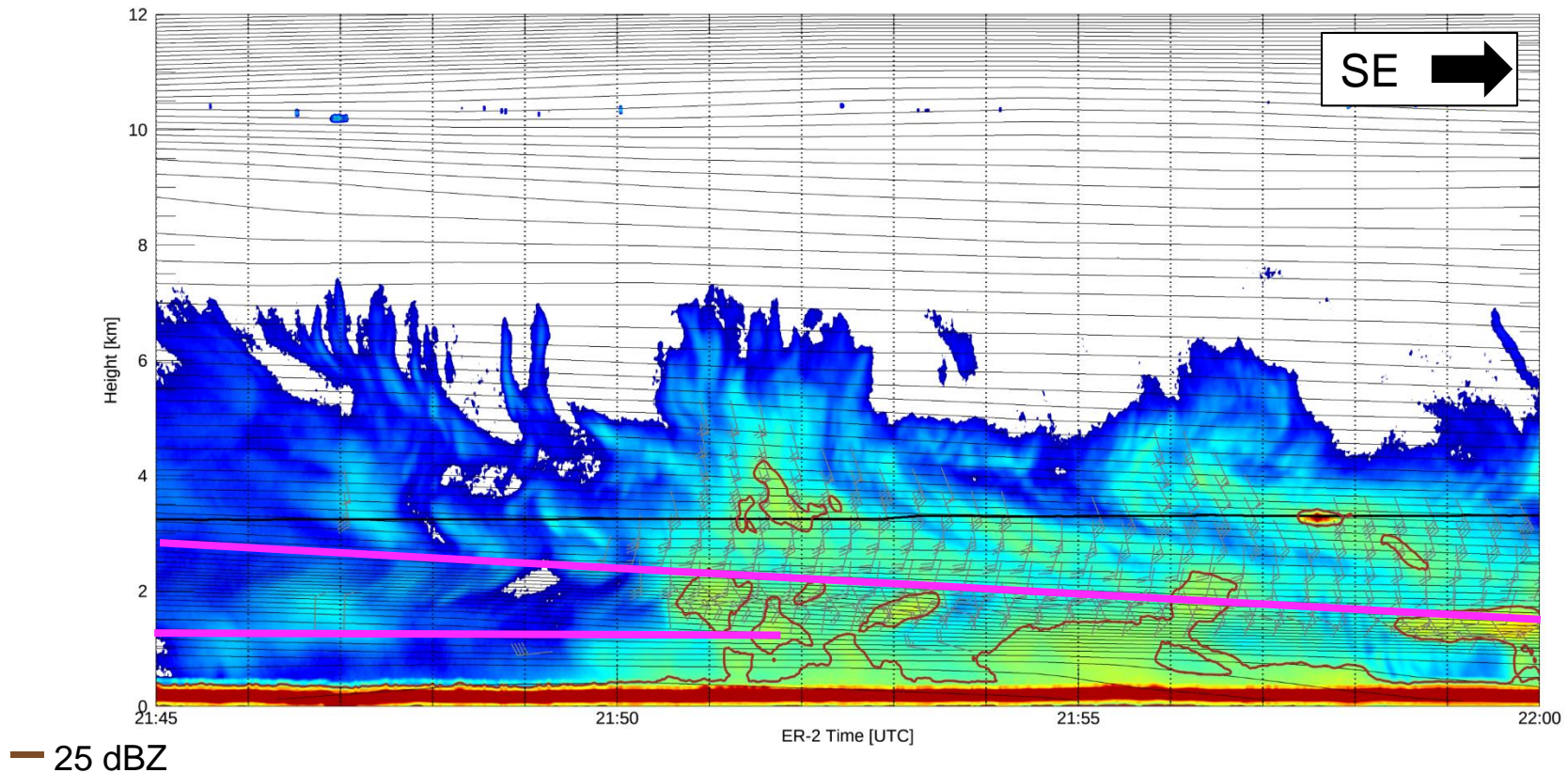Thanks to Peter Pantina for supplying the time-interpolated HRRR fields

Why are these bands where they are?
Frontal features?

Second Pass

EXRAD Reflectivity Curtain :: 202002052145 - 202002052200

21-22 UTC HRRR θ

25 dBZ

Thanks to Peter Pantina for supplying the time-interpolated HRRR fields

Summary

- Looked at the structure of a mesoscale snowband over central Illinois using radar data collected during two flight legs

- Band appears to have a gradual slope
  - Does not appear to be due to isentropic flow
  - Possible relation to particle fall speed in shear?

- Band location
  - Does not appear to be tied to deformation
  - Possible connection to frontal features